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SPECIFICATION

TITLE

METHOD AND DEVICE FOR WIRELESS DATA TRANSMISSION OF DATA ACCORDING TO AN FSK METHOD, ESPECIALLY A GFSK METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a device and method for the wireless data transmission of data according to an FSK method such as the GFSK method, as it, among other things, is used according to the DECT standard.

Description of the Related Art

According to a DECT standard, data is modulated according to a GFSK (Gaussian Frequency Shift Keying) method. For example, David, Benker, "Digitale Mobilfunksysteme, Taeubner Verlag, Stuttgardt", 1996, ISBN 3-519-06181-3 discloses details of the DECT standard. According to the DECT standard, data is transmitted in a frequency range of 1880 to1900 MHz (in the extended case, up to 1930 MHz) in 120 duplex channels having a channel spacing of 1728 kHz. The TDMA access method uses frames of 10 ms. The TDD method is used as duplex method.

For amplitude keying, the amplitude of a carrier wave is changed by the modulation of the data signals, this carrying the information; the frequency, however, remains constant. For frequency keying (FSK, Frequency Shift Keying) the exact opposite is true, i.e., the information is contained in the frequency. The abrupt changeover from one frequency to another, however, leads to relatively high spectral secondary sidebands, so that a high bandwidth is occupied by the transmission signal. A baseband filtering can improve this behavior. A frequency filter g(t) is used, which does not exhibit a rectangular curve but rather a smoothened curve. The smoothing function can be assumed by a Gaussean low-pass filter, for example, thus resulting in a GFSK modulation being received.

The impulse response h (t) of a Gaussean low-pass filter is:

$$h(t) = \sqrt{\frac{2\pi}{\ln 2}} B \exp\left(- \frac{2\pi^2 B^2}{\ln 2} t^2 \right)$$

where B is the 3 dB cutoff frequency. The Gaussean low-pass filter can be switched directly in front of the modulation input of a VCO. Pulses deriving from the convolution of the original rectangular pulses with the impulse response of the Gaussean low-pass filter are then present at the modulation input:

$$g(t) = \frac{1}{2}\left[erf\left(\sqrt{\frac{2}{\ln 2}} \pi B \frac{t + T/2}{T} \right) - erf\left(\sqrt{\frac{2}{\ln 2}} \pi B \frac{t - T/2}{T} \right) \right]$$

Here, erf(x) is the Gaussean error function:

$$erf(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-u^2} du$$

The GFSK transmission filter can be unambiguously marked by its modulation index ("BT relationship"). Figure 6 shows the impulse response of the transmission filter for different modulation indices (BT). It can be seen that the impulse response becomes broader for modulation indices becoming smaller, so that a "partial response" behavior occurs.

For the application in DECT devices, the modulation method GFSK has been specified with a nominal modulation index (BT) of 0.5, which corresponds to a frequency swing of 288 kHz. A range of 202 kHz through 403 kHz is allowable with respect to the frequency swing when the modulation index is fixed.

According to the prior art, the frequency swing is set to a fixed value—thus, an adaptation is not possible.

SUMMARY OF THE INVENTION

Therefore, the present invention is based on the object of creating a possibility for creating the adaptation of a wireless transmission of data according to an FSK method to different environmental scenarios. The present invention, can be applied with respect to all FSK methods and their derivatives.

According to the invention, the frequency swing of an FSK method, for example of the GFSK method, is modified dependent on different parameters.

According to the invention, a method for wirelessly transmitting data according to an FSK method is provided. In this method, data are received and the error rate (BER, Bit Error Rate) of the received data is measured. The field intensity (RSSI value) of the received data is measured at the same time. The error rate and the field intensity are evaluated. Depending on the evaluation of the error rate and the field intensity, the frequency swing of the FSK method used for wirelessly transmitting data is adjusted in order to optimize the transmission behavior.

The frequency swing can be modified within a preadjusted range. The transmission behavior can be optimized on the basis of a table reproducing the obtainable transmission range dependent on the adjusted frequency swing. If the evaluation result is a low field intensity and a low error rate at the same time, the frequency swing, on the basis of the cited table, can be optimized with respect to a maximal range. The transmission behavior can be optimized on the basis of a second table, which reproduces the obtainable interference immunity of the transmission dependent on the adjusted frequency swing. If the evaluation result is a high field intensity and a high error rate at the same time, the frequency swing can be optimized with respect to a maximal interference immunity on the basis of the second table. The transmission can ensue according to the DECT standard. The optimal frequency swing can be selected lower for a maximal range than the frequency swing for a maximal interference immunity.

According to the present invention, a device for wirelessly transmitting data according to an FSK method - as it is used according to the DECT standard, for example - is also provided. The device comprises a receiver and a first measuring device for the error rate (BER, Bit Error Rate) of the received data. Furthermore, a second measuring device is provided for the field intensity during the reception of the data. An evaluation unit processes the measured error rate and the measured field intensity. A control unit is also provided in order to adjust the frequency swing of the FSK method, which is used for the wireless transmission of data by a transmitter, dependent on the measured error rate and the measured field intensity for purposes of optimizing the transmission behavior.

Further features and advantages of the present invention are explained by way of example in greater detail on the basis of an exemplary embodiment and with reference to the appertaining figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram illustrating the structure of an inventive device for wirelessly transmitting data according to an FSK method;

Figure 2 is a logarithmic graph illustrating the bit error rate dependent on the signal-to-noise ratio (SNR) according to a simulation;

Figure 3 is a logarithmic graph illustrating the bit error rate of a wireless transmission dependent on the signal-to-noise ratio for a frequency swing of the disturb signal of 340 kHz,

Figure 4 is a logarithmic graph illustrating the bit error rate dependent on the signal-to-noise ratio for a frequency swing of the disturb signal of 288 kHz,

Figures 5a-d are spectral frequency graphs illustrating the different spectrums of GFSK signals, which have been used for the measuring according to the figures 2 through 4; and

Figure 6 is a response graph illustrating the impulse response g (t) of a GFSK filter.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is generally applied with respect to FSK methods and is described on the basis of an exemplary GFSK method.

The present invention utilizes the phenomenon that a different system behavior of a wireless transmission - dependent on the adjusted modulation index (BT value) of an FSK method (for example, of the GFSK method) - results with respect to the tangential signal sensitivity (range) or the resistance to jamming, for example. If an optimally large range is desired for the transmission, the frequency swing selected therefore inventively differs from the frequency swing of a system that is optimized with respect to maximal resistance to jamming. Thus, according to the present invention, the system is adapted to different scenarios by a corresponding adjustment of the frequency swing (corresponding to a

modulation index) after the bit error rate (BER, Bit Error Rate) and the corresponding RSSI (Radio Signal Strength Indicator, reception field intensity) value have been evaluated.

As shown in Figure 1, digitally modulated signals can be received by an antenna 1 and can be forwarded to a receiver 3. The receiver 3 forwards the received data (RX data) 7, on one hand, and the RSSI value 8, on the other hand, to an evaluation unit 6. More precisely, the receiver 3 forwards the received data 7 and the RSSI value 8 to a control unit 13 in the evaluation unit.

In addition to the control unit 13, the evaluation unit 6 comprises a first table 12 and a second table 14, which are respectively connected to the control unit 13. On one hand, the control unit 13 in the evaluation unit 6 drives a local oscillator (synthesizer) 4 via a control channel 9, which is connected to the receiver 3 and to a transmitter 5 of the mobile radio device 16. On the other hand, the control unit 13 of the evaluation unit 6 drives the frequency swing 10, which is utilized by the transmitter 5. The evaluation unit 6 forwards the data 11 to be transmitted to the transmitter 5, which modulates these data (TX data) 11, with the frequency swing 10 prescribed by the control unit 13, onto the frequency of the local oscillator (synthesizer) 4 and which then forwards them to an antenna 2 for purposes of sending them via a wireless transmission path 15.

The reception data 7 and the RSSI value 8 therefore are transmitted to the control unit 13 in the evaluation unit 6 by the receiver 3. The bit error rate of the received data 7 and the reception field intensity (RSSI value) measured by the receiver 3, by the respective first measuring device 17 and the second measuring device 18, are evaluated in the control unit 13, resulting in the following different scenario:

Case a)

No or little influence by disturbing signals:

The received data 7 have low bit error rates given a low reception field intensity at the same time. In this case, the control unit 13 can drive the frequency swing of the transmitter 5 with respect to a maximal range.

Case b)

Interferences as a result of other signals such as DECT signals:
In this case, the bit error rates are relatively high given relatively high reception field intensities. In this case, the control unit 13 of the evaluation unit 6 controls the frequency swing of the transmitter 5 with respect to maximal interference immunity.

The first table 12 and the second table 14 are provided in the evaluation unit 6 for optimizing the system with respect to a maximal range or a maximal interference immunity. The first table 12 indicates the maximally obtainable range of the wireless transmission dependent on the frequency swing that can be selected within an allowed range. The second table 14 represents the maximal interference immunity dependent on the frequency swing.

The tables 12 and 14 are prepared, for example, prior to the actual transmission, by an analysis of the system behavior of the wireless transmission 15 by simulations with different frequency swings. In Figure 2, the bit error rate has been calculated dependent on the signal-to-noise ratio. The curves entered in Figure 2 represent the following cutoff data: 1) Frequency swing of 202 kHz: Lower limit of the allowed standard, 2) Frequency swing of 288 kHz: Nominal value, 3) Frequency swing of 340 kHz: Frequency swing as it is firmly adjusted in some devices according to the prior art, and 4) Frequency swing of 403 kHz: Upper allowed limit of the DECT standard.

It can be concluded, by evaluating the diagram shown in Figure 2, that a frequency swing of 340 kHz is to be adjusted for a system that is optimized with respect to maximal range; this corresponds to the above-cited case a).

The characterizations of the resistance to jamming of a DECT connection (case b)) derive from further simulations. According to the calculations shown in the Figures 3 and 4, it can be seen that the coexistence of different systems should be continued to be viewed in this scenario. For a disturbing signal having a 340 kHz frequency swing (e.g., neighboring traditional DECT systems), the optimal frequency, as it should be utilized with respect to the present invention - is also at 340 kHz (see Figure 3). According to the present invention, the nominal frequency swing of 288 kHz is adjusted for co-channel interferences with respect to all systems (Figure 4).

Figures 5a through 5d show the test signals utilized during the simulations.

According to the present invention, an adaptation of the system to different scenarios can be undertaken by evaluating the bit error rate and the corresponding RSSI value by a corresponding adjustment of the frequency swing of an FSK transmission.

The above-described method and device are illustrative of the principles of the present invention. Numerous modifications and adaptations thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.